



NAVAIR Hexavalent Chromium Minimization Status

SERDP/ESTCP Symposium 2010

Cr⁶⁺ Session

Bill C Nickerson

AIR 4.3.4



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14. ABSTRACT NAVAIR has set forth a comprehensive goal for the development and qualification of nonchromated materials. Candidate alternative materials have often been developed and evaluated to the bare minimum of performance requirements, leading to reduced corrosion protection and loss of robustness in the materials protection scheme. The NAVAIR nonchromated materials goal is to: Identify, test, validate and implement non-chromate, Class N primers and surface preparations which are as broad in capabilities and performance as current chromated, Class C, primers and surface preparations. To this end, demonstrated capabilities must include performance across multiple alloys/substrates, with and without subsequent topcoats and specialty coatings. Alternative materials must perform a variety of uses, such as protection of faying surfaces, galvanic corrosion protection in dissimilar materials interfaces, wet installation of fasteners and bushings, resistance to SCC, embrittlement and exfoliation damage and other traditional uses of chromate primers, metal finishes, and sealants. Coatings must perform over Type I and Type II conversion coatings per MIL-DTL-81706/MIL-DTL-5541. Additional surface conditions/finishes that the coating must demonstrate compatibility and full performance over are finishes such as: Type I, IC, II, or IIB anodized aluminum per MIL-A- 8625, sacrificial coatings (such as IVD-Al, Cd, Zn-Ni, etc.), touch-up on Fe alloys, other conversion coated or anodized light metals such as Ti, Mg, and Zn, and composite substrates. Full implementation will also require demonstration of equivalent performance in adhesion filiform, humidity, and fluid resistance properties for all the materials and applications currently protected by Class C coatings and finishes. This talk will address the current and planned alternative materials efforts, status of approval and technology implementations, and identify gaps and shortfalls in the current technologies.		

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NAVAIR NON-CHROMATE MATERIALS STATUS

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NAVAIR has set forth a comprehensive goal for the development and qualification of non-chromated materials. Candidate alternative materials have often been developed and evaluated to the bare minimum of performance requirements, leading to reduced corrosion protection and loss of robustness in the materials protection scheme. The NAVAIR non-chromated materials goal is to: Identify, test, validate and implement non-chromate, Class N, primers and surface preparations which are as broad in capabilities and performance as current chromated, Class C, primers and surface preparations. To this end, demonstrated capabilities must include performance across multiple alloys/substrates, with and without subsequent topcoats and specialty coatings. Alternative materials must perform a variety of uses, such as protection of faying surfaces, galvanic corrosion protection in dissimilar materials interfaces, wet installation of fasteners and bushings, resistance to SCC, embrittlement and exfoliation damage, and other traditional uses of chromate primers, metal finishes, and sealants. Coatings must perform over Type I and Type II conversion coatings per MIL-DTL-81706/MIL-DTL-5541. Additional surface conditions/finishes that the coating must demonstrate compatibility and full performance over are finishes such as: Type I, IC, II, or IIB anodized aluminum per MIL-A-8625, sacrificial coatings (such as IVD-Al, Cd, Zn-Ni, etc.), touch-up on Fe alloys, other conversion coated or anodized light metals such as Ti, Mg, and Zn, and composite substrates. Full implementation will also require demonstration of equivalent performance in adhesion, filiform, humidity, and fluid resistance properties for all the materials and applications currently protected by Class C coatings and finishes. This talk will address the current and planned alternative materials efforts, status of approval and technology implementations, and identify gaps and shortfalls in the current technologies.

NAVAIR Non-Chromate Coatings Goal



Identify, test, validate and implement non-chromate, primers and surface preparations which are as broad in capabilities and performance as current chromated primers and surface preparations.

- Performance across multiple alloys/substrates, with and without topcoats per MIL-PRF-85285 and TT-P-2760; in combination with specialty coatings
- Across all exposure conditions for all the materials currently protected by Class C materials.
- Galvanic Corrosion Protection – faying surfaces, dissimilar materials interfaces, wet installation of fasteners and bushings, SCC, exfoliation, etc.
- Surface Prep/Primer Compatibility –
 - Type I and Type II conversion coatings per MIL-DTL-81706/MIL-DTL-5541
 - Type I, IC, II, or IIB anodized aluminum per MIL-A-8625
 - Sacrificial coatings (such as IVD-Al, Cd, Zn-Ni, etc.)
 - Fe alloys, other conversion coated or anodized light metals such as Ti, Mg, and Zn, and composite substrates
 - Adhesion, filiform, humidity, and fluid resistance properties





Policy and Technology Drivers

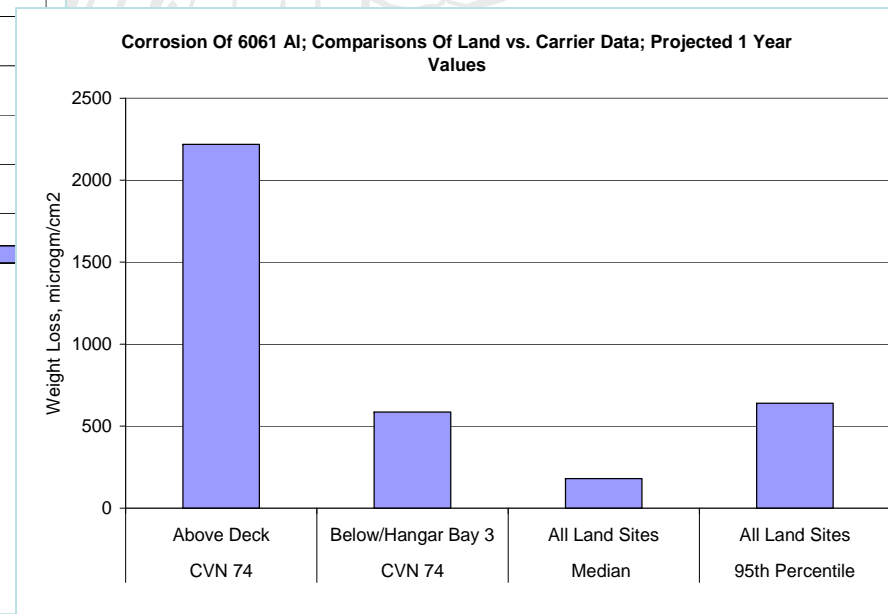
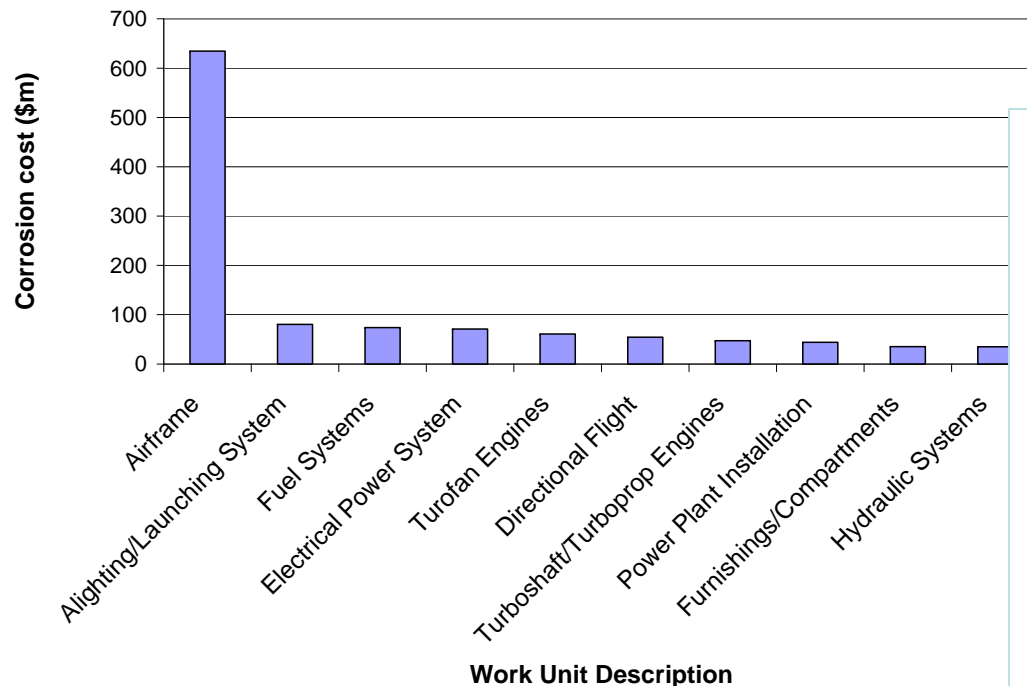
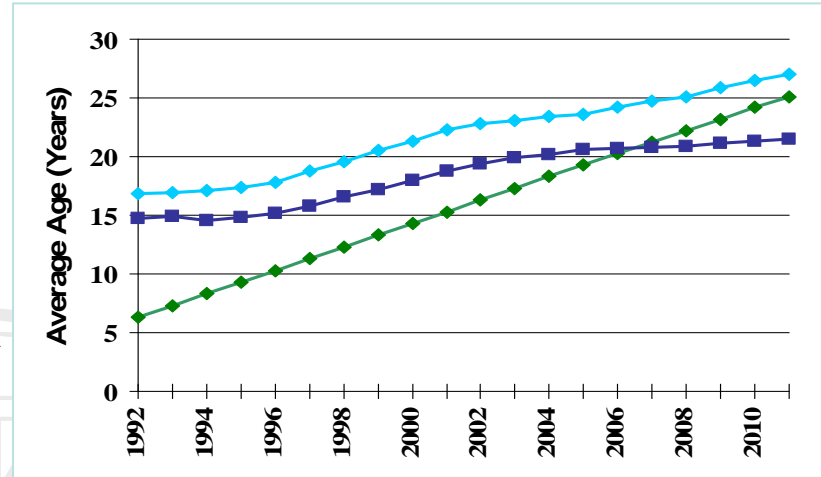
- Environmental Regulatory –
 - OSHA PEL, RoHS, WEEE, REACH, EO
- DoD Policy –
 - DUSD AT&L Policy Memo Minimizing the use of Hexavalent Chromium (Cr^{6+}) – 8 Apr 2009
- Technology –
 - Performance, Durability, Reliability, Maintainability
- Cost –
 - Cost of Corrosion – Increasingly complex, expensive systems
 - Focus solely on ESOH reduced robustness of protective materials and coatings
 - Aging Aircraft – Flying beyond predicted service life





Operational Reality

- Extremely Harsh Environment = High Life Cycle Cost
 - True for current environmentally unfriendly yet robust materials
 - Factors: TMS, # in inventory, average age/flight hours, airframe corrosion ~7X





NAVAIR Transition Strategy

- Engage all relevant levels and user communities –
 - Military & Commercial OEM's
 - Depot/Manufacturing Sites
 - Industry Partners, Chemical Manufacturers
 - O-level activities
 - Research & Development, Demonstration/Validation, Specifications, Technology Transition
- Implementation Path –
 - Lab validation – process and product performance
 - Field validation – process and product performance
- Risk Analysis & Mitigation – Application Axis vs. Platform/Basing Axis





Proposed NAVAIR Policy/Procedure

- Take a Command-Wide Approach
 - Command Response with PEO concurrence
 - Establish a Cr⁶⁺ Usage Certification Process
 - Communicate state-of-the-art alternatives
 - Establish risk reduction process that accounts for performance/technical, environmental and logistics factors
- Establish a NAVAIR Cr⁶⁺ Elimination Task Force Team
 - Develop Action Plan (Command)
 - Identify command use, applications, and current/future mitigation strategies
- Document, assess, monitor, track the use of Cr⁶⁺
 - Program and budget for mitigation of environmental regulations
- AIR 4.3 Engineering Circular –
 - Uniform guidance for PMA's



Non-chromate Coatings Engineering Circular

XX Date 2010

EC-434-xxx-2010

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EC - 434 - XXX - 2010

**NON-CHROMATE
COATINGS SYSTEMS**

NAV AIR

Month XX, 2010

AIR VEHICLE ENGINEERING (AVE) DEPARTMENT
NAVAIR AIR SYSTEMS COMMAND

Distribution: _____ Initiated By: AIR 4.3.4

Risk Analysis for Implementation of Non-Chromate Technology

Probability of Failure for Non-Chromate Technology vs. Chromate*	Impact of Non-Chromate Technology Failure			
	Mishap, Replacement	Reduced Service Life, High Repair Costs	Increased Maintenance Activities	Negligible
High				
Medium				
Low				
Same as Chromate				

* Probability of failure of non-chromate technology based on sufficient laboratory testing, comparison to current chromate technology for a particular application, and AIR-4.3.4 endorsement.

High Risk	Critical Application Areas should be avoided until test data supports lowering risk level. Ex. Critical Safety Items (CSI), susceptible to stress corrosion cracking (SCC), high cost for repair, inaccessible areas, etc. **
Medium Risk	Application Areas that need careful consideration and review based on test data. Ex. outer-mold-line, inner-mold line, faying surfaces, direct to metal, metal-to-composite contact, etc. **
Low Risk	Non-Critical Application Areas suitable for Dem-Val/Implementation based on test data. Ex. composites without metallic contact, fiberglass, low impact - low cost components

** Note: Factors such as platform/component operational environment and inspection intervals must be considered and may justify adjustment to the risk analysis level. Ex. Trainer aircraft operate in a less severe environment than ship based aircraft.

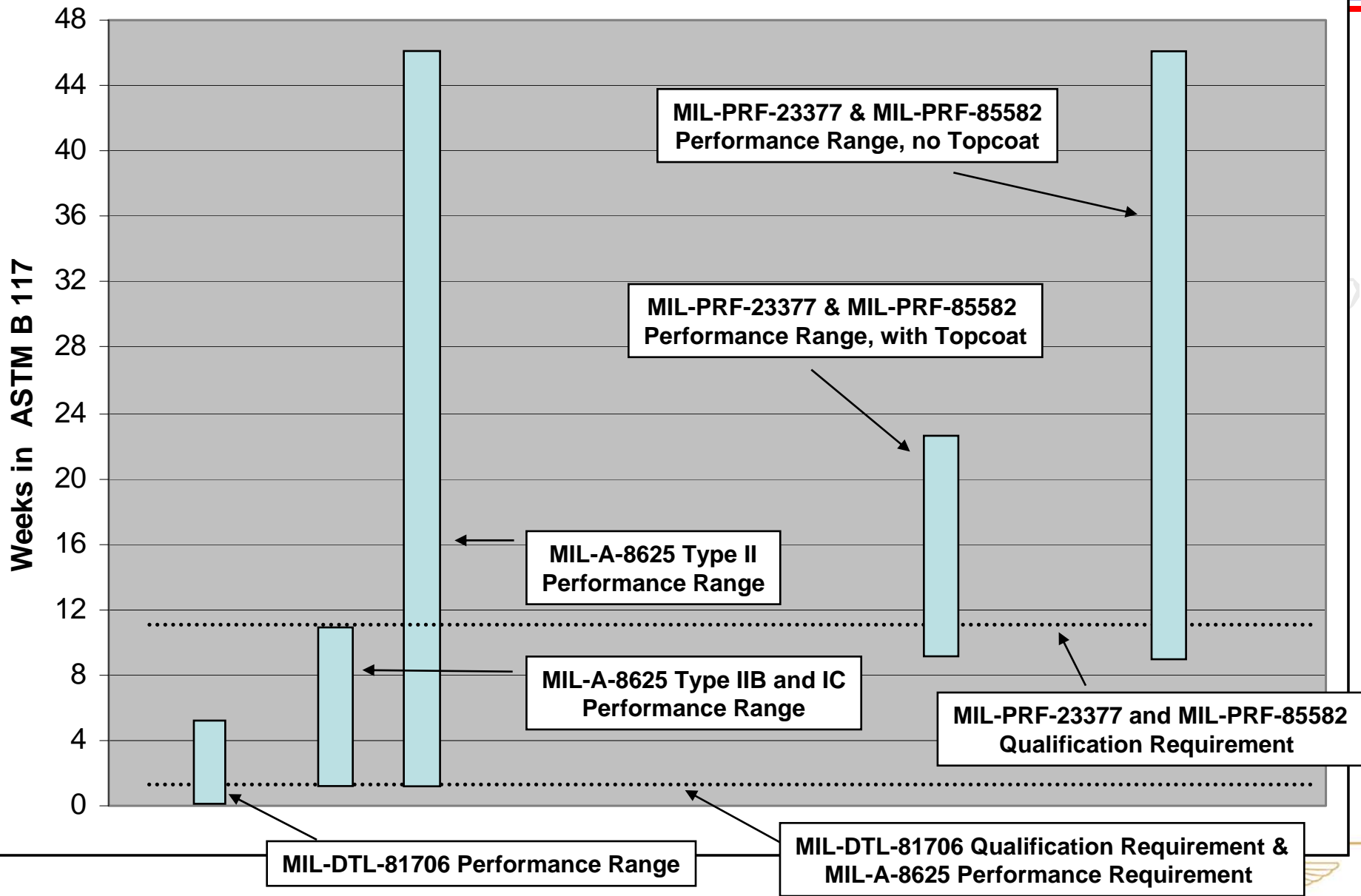


Accelerated Testing

- High-Solids / Water-Reducible Chromate Primers – initial 1000 hours in ASTM B117 (MIL-P-23377 rev F/1989)
 - Based on QC of **established** chromate pigments/coating performance on aircraft
 - Class N products in each spec, 2000 hours for both specs, all primers
 - Change made without field data to establish correlation to accelerated tests
- Presumed performance to spec tests would yield good field performance based on known chromate chemistry –
 - Galvanic couples, beach/real world exposure, barrier properties, substrate/surface preparation compatibility – Not reflected in specification testing
 - **Minimum performance based on quality control does not equal similar performance when trying to validate and authorize new coatings**
 - Unknown correlation of performance of new non-chromate inhibitor chemistries in field compared to accelerated corrosion tests
 - Large differences in performance for solvent-borne vs. water-reducible primers in galvanic tests regardless of inhibitors – Solvent-borne typically better in lab test data
 - Non-chromate primers tend to rely more on pretreatment performance
 - No general guidance exists on how to use tests, suggested combinations of alloys and tests, comparative data of accelerated tests versus beach exposure



Test to Failure vs. Qualification Criteria





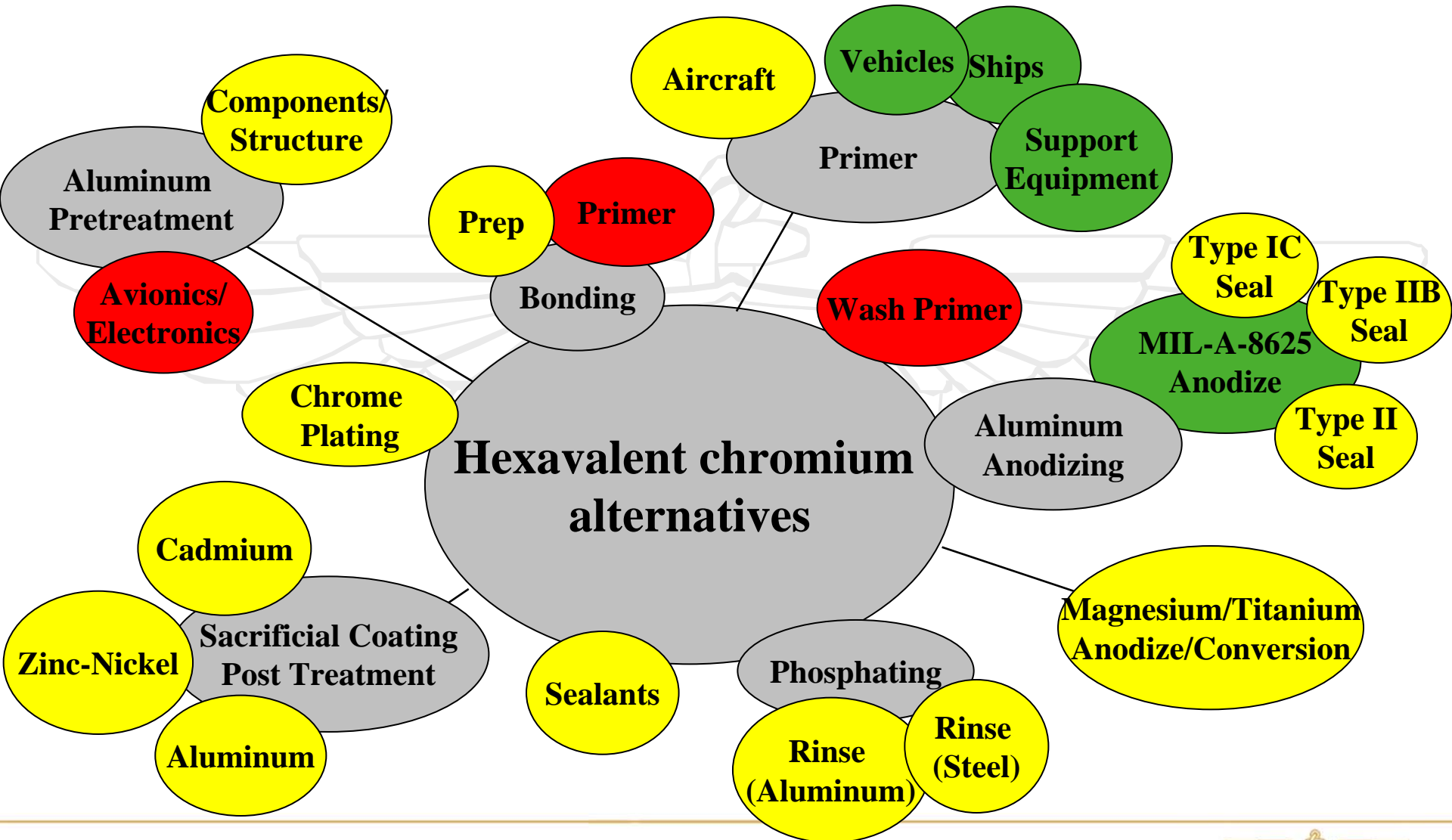
Non-chromate Coatings Test Protocol

ESTABLISH STANDARD PRACTICE – Minimize or eliminate false positives and negatives in accelerated testing

- Use AA2024-T3 and AA7075-T6 aluminum panels. Use 1 sacrificial coating plated over high strength steel, such as IVD-Al/4340. Use standard 1018/1020 LC steel panels.
- Accelerated Test: ASTM B 117 Neutral Salt Spray, ASTM G 85 Annex 4 Acidified SO₂ Salt Spray, and GM9540P Cyclic Corrosion, and ASTM D 2803 Filiform Corrosion Resistance.
 - Run beyond the normal “minimum” specification requirements – 3000 hours in ASTM B 117, 1000 hours in ASTM G85 Annex 4, 120 cycles in GM9540P, and 2000 hours in ASTM D 2803.
- 1+ year minimum beach exposure test – at a facility with a documented salt-laden, corrosive local environment, such as the Kennedy Space Center corrosion test facility.
- Evaluate coatings in faying surface and fastener dissimilar metal couples, as well as with any specialty coatings, always with a known chromate control.
- Test all non-chromate primers in conjunction with currently authorized and promising non-chromate metal finishing technologies, i.e. MIL-DTL-81706, MIL-A-8625, TT-C-490, MIL-DTL-84388, etc.
- Evaluate alternatives with and without topcoat and with simulated damage (scribes) through the coating systems.
- As improved corrosion test methods become available, combine the test protocol with improved accelerated exposures.
- Test in faying surface and fastener dissimilar metal couples
- Evaluate compatibility with composites substrates, ceramics, and other electroplated/mechanically deposited coatings



Application Areas for Chromate Alternatives





Finishing Applications

- Conversion Coatings – Aluminum, Magnesium, Titanium, Zinc
- Anodizing Sealing – Aluminum Anodizing Sealing
- Sacrificial Coatings – Cd, Zn/Zn Alloys, IVD-Al/Aluminum Plate
- Phosphate Rinsing – Zn/Mn/Fe Phosphate
- Rust Inhibiting Coatings – Fe & Steel Alloys
- Wash Primers – Multiple Substrate Processing
- Mechanical Coatings – Hard Cr, HVOF, CS
- Process Chemicals – Cleaners, Degreasers, Etchants, Deoxidizers
- Process Solutions – Chemical Conversion, Anodize/Anodize Rinsing
- Organic Films – Epoxy Primer, Alkyd Primer, Polyurethane Primer
- Adhesive Structural Bonding – Sol-gel, Anodize, Bond Primers
- Sealants – Polysulfide, Polythioether, Sealants, Polyurethane





Authorization/Implementation Status

M&P Area	Sub Area	Location	Process Status	wt vol% of Cr6+ in NAE	%of Cr6+ eliminated
Painting/Primer	Support Equipment	Depot and Field	Non-chromate primer in use (MIL-DTL-53022) for all applications	0	100
	Aircraft and Components	Depot and Field	Non-chromate primer authorized scuff sand and overcoat of chromate primer. Limited demonstrations underway direct to metal on fleet C-2s. More demos planned for FY11+.	TBD	TBD
Adhesive Bonding		Depot and Field	Alternative not authorized	TBD	0
Sealing		Depot and Field	Non-chromated sealants are available but have not been transitioned to depot and field applications (field introduction controlled through new acquisition programs)	TBD	0
Aluminum Pretreatment	Avionics/Electrical	Depot and Field	Alternative not authorized. Class 3 demonstration and validation efforts proposed for FY11. Leveraged with NASA effort.	TBD	0
	Components/Structure	Cherry Point-Aircraft re-paint (spray)	Authorized for use under chromated primer (TCP). Demonstration and validation underway assessing TCP with leading NC primer on aircraft.	TBD	100
		North Island- Aircraft re-paint (spray)		TBD	0
		Jacksonville- Aircraft re-paint (spray)		TBD	0
		Cherry Point- Component Immersion tanks		TBD	0
		North Island- Component Immersion tanks		TBD	0
		Jacksonville- Component Immersion tanks		TBD	0
		Field		TBD	0
Aluminum Anodizing	Sealing Type II & III	Cherry Point	Authorization of alternative (MIL-DTL-81706 Type II TCP products) pending authorization letter in FY10. Jacksonville planning to implement TCP as soon as authorization is issued.	TBD	0
		North Island		TBD	0
		Jacksonville		TBD	0
	Sealing Type IC	Cherry Point	Authorization of alternative (TCP) pending.	TBD	0
		North Island		TBD	0
		Jacksonville		TBD	0
	Sealing Type IIB	Cherry Point	Type IIB not authorized currently. Dem/val underway to produce data for potential authorization as Type IC alternate. Being considered by Jacksonville as part of single tank Type II, IIB and III anodize system. Authorization of alternative (TCP) pending.	TBD	0
		North Island		TBD	0
		Jacksonville		TBD	0



Authorization/Implementation Status

Sacrificial Coatings	Cadmium Post Treatment	Cherry Point	Authorization of alternatives pending review of available data	TBD	0
		North Island		TBD	0
		Jacksonville		TBD	0
	IVD Aluminum Conversion	Cherry Point	Authorization of alternative (TCP) pending results of field testing.	TBD	0
		North Island		TBD	0
		Jacksonville		TBD	0
	Zn-Ni Post Treatment	Cherry Point	Authorization of alternatives pending review of available data	TBD	0
		Jacksonville		TBD	0
	Alumiplate	OEM/supplier	MIL-DTL-81706 Type II (TCP) conversion coating authorized	TBD	0
Magnesium Anodize and Conversion Coating		Cherry Point	Tagnite and HAE anodize processes authorized for OEM application. Authorization pending for conversion coating alternative use in component recoating and touch up (Alodine 5700 and TCP)	TBD	TBD
		Jacksonville		TBD	0
		Field	Authorization pending for conversion coating alternative use in component coating touch up (Alodine 5700 and TCP)	TBD	TBD
Hard Chrome Plating		Cherry Point	WCCo and WCCoCr HVOF coatings authorized; limited to low stress/spalling risk applications. CoP plating in dem/val through ESTCP project.	TBD	TBD
		North Island		TBD	TBD
		Jacksonville		TBD	TBD
Titanium Conversion Coating		Depot and Field	Authorization of alternatives pending review of available data	TBD	TBD
Phosphating	Steel, "rinse"	North Island	Mn-phosphate process with chromate rinse. New alternative being assessed (ChromiPhos) as part of ESTCP project with the Army.	TBD	0
		Jacksonville	Phosphate process with chromate rinse. ChromiPhos being assessed.		
		Cherry Point	Zn-phosphahate process with chromate rinse. New ChromiPhos being assessed.	TBD	0
Fuel Tank Coating		Depot and Field	Alternative not authorized	TBD	0
EMI Shielding, Conductive Coatings and Sealants		Depot and Field	Alternative not authorized	TBD	0
Cleaners		Depot and Field	Non-chromate products implemented	TBD	100
Deoxidizers		Depot and Field	Non-chromate products implemented	TBD	100



R&D Efforts and Needs

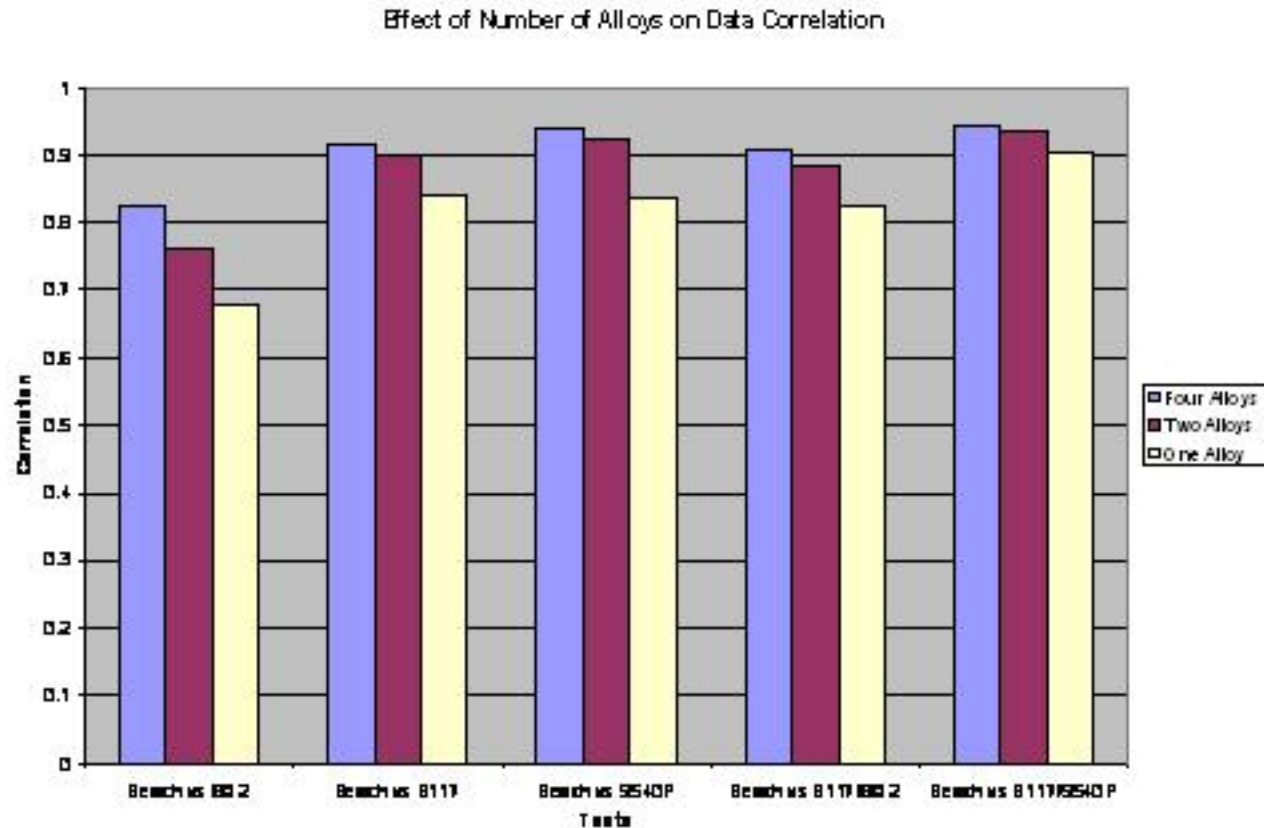
- Correlation of accelerated corrosion test results with results of natural, beach front and ship-board exposures
 - **“Cherry Picking” alloys and accelerated tests leads to strong false positives and negatives**
- Aerospace is last “hold-out” for Cr⁶⁺ use in protective coatings
 - Navy and Marine Corps operating requirement is most challenging
 - Alternatives acceptable for automotive, commercial aviation, land-based DoD are typically not good enough
 - Simulation of operating environment a challenge for RDT&E and acquisition/design trade studies
- Additional challenges – Mechanisms, HAP/VOC, Logistics
 - Basic understanding of corrosion protection mechanisms for qualified and emerging non-chromated, proprietary inhibitors
 - Basic understanding of inhibitor effects on stress-corrosion cracking and corrosion fatigue
 - Primers with improved flexibility, high adhesion and easy removal, improved processing characteristics
 - Reduce or eliminate VOCs/HAPs/TRI chemicals from current coating systems



Assessment of Accelerated Tests Compared to Beachfront Test and Proposed Evaluation Method



Tests	Correlation
Beach vs B117	0.915
Beach vs 9540P	0.94
Beach vs SO2	0.825
Beach vs B117/SO2	0.908
Beach vs B117/9540P	0.943



Dynamic Accelerated Corrosion Testing Methodology

Deliverables

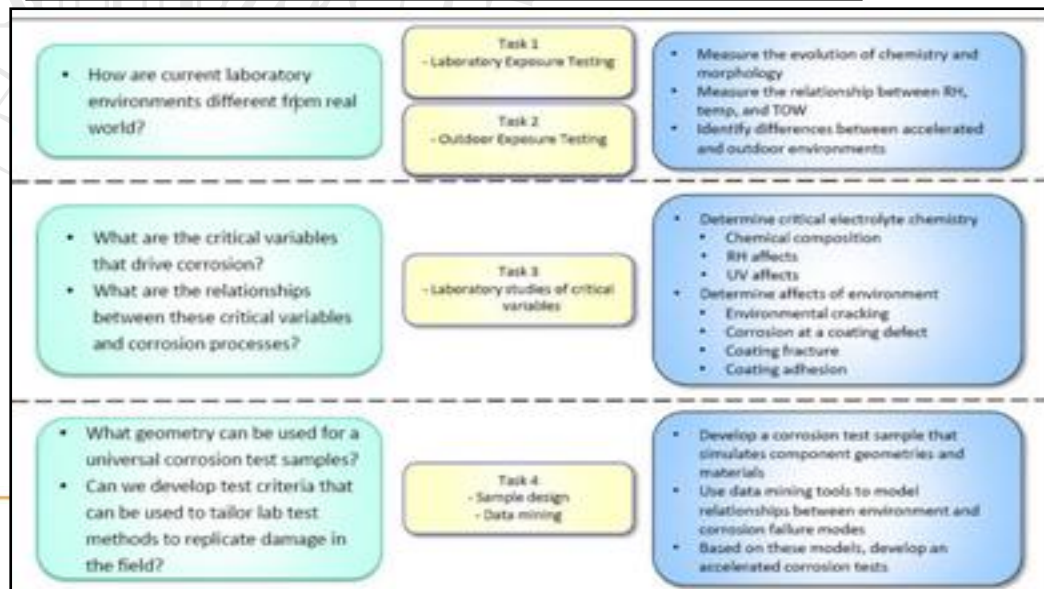
- Accelerated corrosion test method that more accurately predicts component failure modes as a function of environment and can discriminate relative performance of material systems
- A means to implement mechanical loading into accelerated corrosion tests to simulate coating and structural material failures
- Improved understanding of the relationship between environmental parameters and corrosion failure modes
- A data mining tool that can be used to tailor laboratory tests to excite various combinations of failure modes
- 1 MS and 2 Post Docs from UVA
- Peer reviewed publications

Technical Objectives

- Integrate representative sample designs into accelerated corrosion testing
- Integrate mechanical loading into accelerated corrosion testing
- Characterize and compare the development of the corrosion electrolytes for “real world” and current accelerated corrosion tests
- Determine the effect of critical environmental and mechanical parameters on degradation modes of system components
- Develop an AI framework to tailor the accelerated corrosion test to real world failure modes

Problem Statement

- Advanced materials for improved performance are being implemented on new and legacy systems
- Limitations of current corrosion testing
 - Long term testing is rate limiting for technology implementation
 - Short term laboratory testing is proving inadequate for predicting long term performance (i.e. promising technology fails lab testing while poor technology passes lab testing)
- Need to improve accelerated corrosion testing
 - Differentiate candidate materials
 - Accelerate “real world” failure modes





NAVAIR Coating Stack-up Effects

- Aluminum Surface Preparation – Anodize > A1200S ≥ TCP > A5200/5700
 - Most consistent performance with/across substrates, primers, materials and exposures – No interest in “muddled middle” or sub-tier adhesion promoters
- **Adhesion is not the only story –**
 - **Clear positive impact of “passivation” character of CC on surface**
 - **Clearly seen in galvanic and beach exposures**
- Ferrous Alloy Preparation –
 - Most demonstration and validation of chromate alternatives has focused only conversion coating of aluminum and outer mould-line primers
 - There remains a need to demonstrate and validate effective replacement technology for applications on steel
 - Elimination of chromated wash primers and many chromate-rinsed phosphate processes reduced overall protection of coating systems





NAVAIR Primer Efforts

- Silver” Standard – MIL-DTL-5541 Type II/MIL-PRF-23377 Type I –
 - Most applications covered – 95+% solution – Next Gen Primer needed
 - Robustness is Key – Most robust surface preparations + most robust organic coatings = Most robust coating systems
 - Misconception regarding resins – 340 g/L
- Resin Properties often overlooked –
 - Inhibitor is not the only functional component, adhesion and barrier properties controlled by resin system
 - Also impacts pigment loading and inhibitor release function
 - 23377 High-solids “solvent-borne” superior resin system for total protection
 - 85582 “Waterborne” inferior galvanic corrosion protection, better application characteristics
 - Effect more pronounced in Class N primers
 - Rely more on surface preparation performance
 - Example – Deft 02GN084 > Deft 44GN098 > Deft 65GN015D





NAVAIR Non-Cr6+ Efforts

- AERMIP – GSE focused – Dem/Val Class N primer/ZVOC topcoat
- NESDI – Current “silver-standard” approach – support DEM/VAL
 - Best available technology, limited/lower risk implementation
- ESTCP WP 0731 – Project ended FY09 – Magnesium-rich Primer
 - Performance issues in primer only condition, galvanic assemblies (with or without topcoat), and beach exposures that show rupturing/tunneling failures through the coating and self-corrosion of the primer itself
- ESTCP WP-1010 – Project scaled back in scope – E’coat Primer
 - Promising barrier properties and coating uniformity for complex geometries. Uses an organic inhibitor in a conductive polymer resin. Performance issues for protection of scribed/damaged areas in initial corrosion testing.
- NISE/NASA – Type II, Class 3 Conversion Coatings
 - Lab Validation and Dem/Val for Electronics Applications

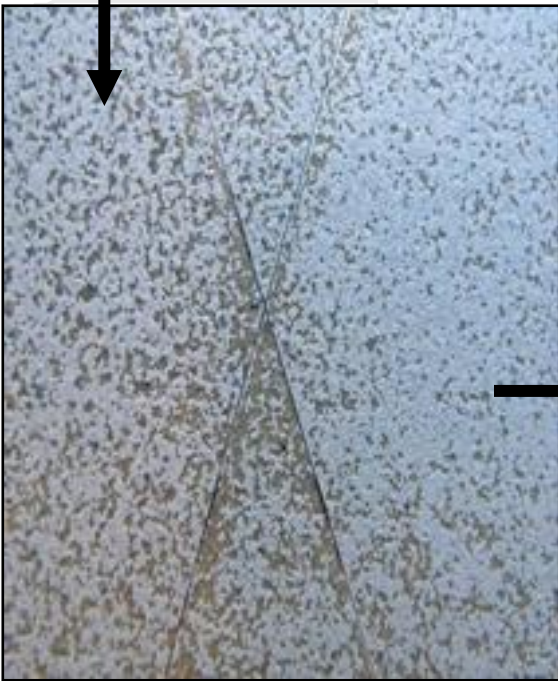
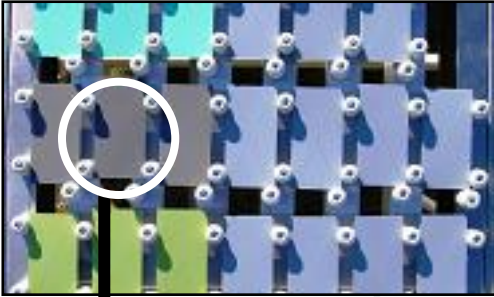


MIL-PRF-23377 Class N Dem/Val

- Objective: Transition Type I non-chrome primers across all gloss paint T/M/S to eliminate Cr6+ in primers by FY12
- DEM/VAL four E-2 Hawkeyes using the leading Class N primer
 - Follow on – Obtain authorization to DEM/VAL on F/A-18s
 - E-2/C-2 DEM/VAL with Type II conversion coating + Class N primer



Performance Evaluation of a Magnesium-Rich Primer (Project WP 0731)

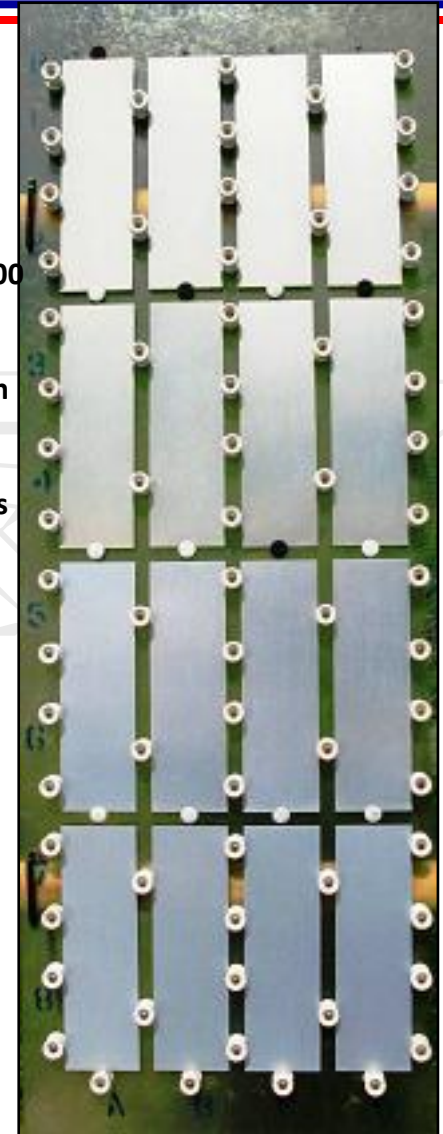


Surface after 15-month exposure
(April 2009)



Surface after 22-months
(September 2009)

Alodine 1600
TCP
Bare
conversion
coating
surfaces
18-months



NC/ZVOC Coatings for Fe Substrates – WP-200906

- Most demonstration and validation of chromate alternatives has focused only conversion coating of aluminum and outer mould-line primers.
 - There remains a need to demonstrate and validate effective replacement technology for applications on steel



Non-chromate, Zero-VOC Coatings for Steel Substrates on Army and Navy Aircraft and Ground Vehicles

Project WP-200906

Jack Kelley
US Army Research Laboratory

In-Progress Review Meeting
October 26-27, 2010





Advanced Anodizing using Process Control Technology

NESDI N-0086-02: Low HAP Coatings, Solvents and Strippers.

- Integration of Metalast Process Control technology for producing Type II, IIB & III coatings within one tank system for Depot-Level maintenance
 - Metalast Process Control Technology to include Interface Controller, Process Controller & Bath Additive
 - Evaluate TCP as a non Cr+6 post anodize sealer for all coating types.
- ROI: 30.7 or Payback Period of 2.1 Yrs

Tank	Process	Volume(gals)
3	Conv Coat	390
8	Conv Coat	600
9	Andz Sealer	1,885
12	Deox	1,885
30	Mag Treat	730
205	Deox	260
212	Andz Sealer	260
	Total	6,010

Potential Replacement with TCP

NESDI Project will lead to >35% volume reduction of Cr⁺⁶ usage in FRC-SE Treatment Shop

Capabilities gained:

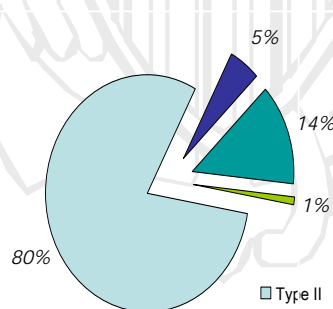
- Reduces Operator error and Supervision of Process
- Improved quality, accuracy and repeatability
- Reduces defects and rejects
- Accountability of Work Performed

Efficiencies achieved:

- Reduces cycle & throughput times
- At least 15% more efficient than conventional anodizing

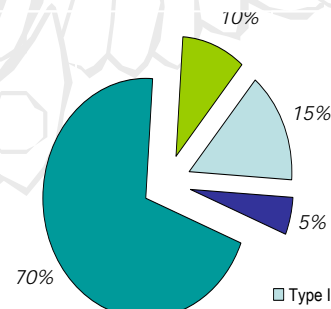
Environmental benefits achieved:

- Extends life of bath chemistry/ Reduced Waste
- Energy savings due to use of aluminum cathodes
- Allows for consolidation of anodizing processes
- Elimination of Hexavalent Chromium



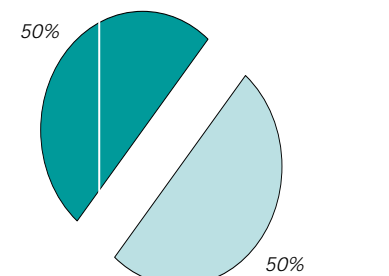
Type II
Type III
Type IC
Type IC Fatigue Critical

FRC-SE (JAX)
Fully Integrated



Type II
Type III
Type IC
Type IC Fatigue Critical

FRC-E (CP)
Fully Integrated

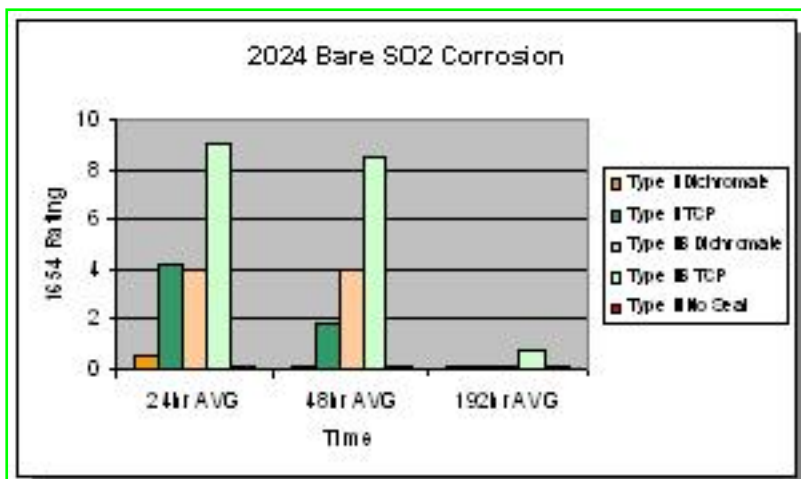


Type II
Type IC

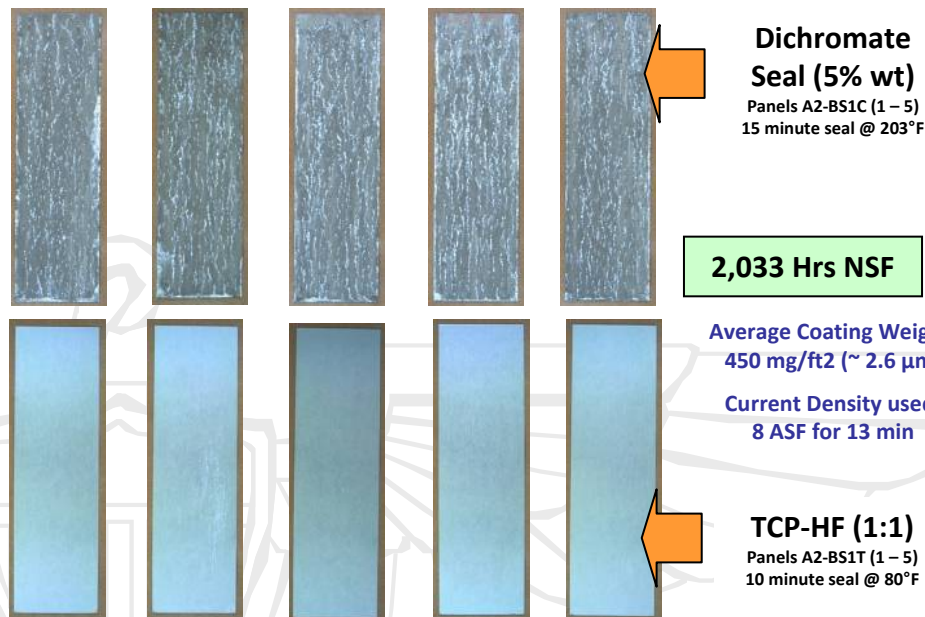
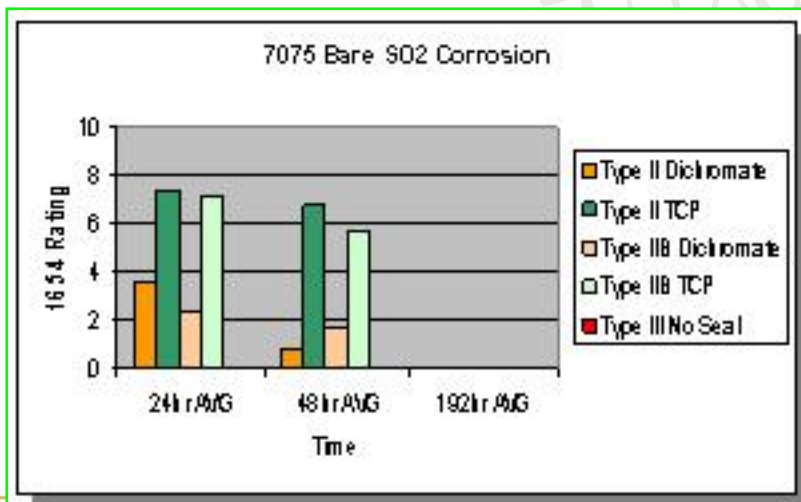
FRC-SW (NI)
Integration in Process



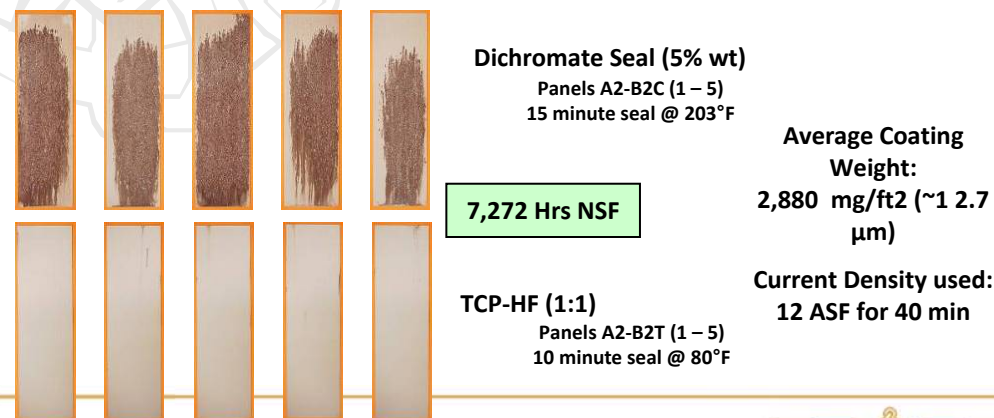
Advanced Anodizing using Process Control Technology



TCP shows better performance than Dichromate Sealing



Type IIB TCP sealed coupons went well beyond 3,000 hrs before significant pitting corrosion was visible



ESTCP Comprehensive Evaluation and Transition of Non-chromated Primers



Technical Objectives

- Develop an application matrix to map candidate technologies to proposed uses, and provide design space guidance to researchers and developers.
- Provide a “top down” assessment of current NC primer technology, including coating process manufacturing readiness level and coating technology readiness level.
- Develop and publish DoD/service testing guidelines which will support authorization and implementation by appropriate technical authorities.
- Demonstrate and validate NC primers and processes with sufficient process and coating maturity.
- Invest in development of promising newer technologies which have the potential to exceed the performance of today’s best NC primers or provide significant cost savings to standard “wet” paint processes.
- Modify MIL-PRF-23377 and MIL-PRF-85582 to account for improved testing methods and potential new types of primers like metal rich, e-coat, and UV-cured products.

